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Comparison of two lateral move irrigation machines commonly used in Turkey in respect of water uniformity coefficient

Türkiye'de yaygın olarak kullanılan iki doğrusal hareketli sulama sisteminin eş su dağılım katsayısı açısından karşılaştırılması

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Ö Z E T / A B S T R A C T

Aims: The purpose of this paper is to define some criteria such as uniformity coefficient, features of machines, which is used commonly in Thrace region for field crops to be used in system design. In this study, the water distribution tests were performed standards and the Christiansen's uniformity coefficient (CU) was determined in order to control the uniformity of the water distribution throughout the wings.
Methods and Results: Within the scope of the test, 6 mm nozzle diameter, 30, 40, and 50 m h^{-1} operating speed were used. The wind velocity and prevailing direction is the factor that causes negative influence on water application. Therefore, they were taken into consideration the wind velocity from 0.5 m s^{-1} to 2 m s^{-1}. The performance test was applied on two different types of irrigation movement machines that have different wing lengths, where 11 and 17 collectors were placed on the left and the right side of the wings. The amount of water collected in the collectors was measured and CU was calculated. As a result, water uniformity coefficients values were varied between 74.72-86.50%.
Conclusions: It is advantageous that the wing height and length of one of the machines can be adjustable, it is advantageous that the flow and speed control of the other one's can be done with electronic panel. So, these machines should be tested and developed by crop cultivation.
Significance and Impact of the Study: The importance of the study is to improve the system performance, to ensure uniform water distribution on the field surface, to improve the water application efficiency and to develop recommendations for machine manufacturers and users in parallel to increase production capacity.

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INTRODUCTION

Water is being applied to millions of acres of irrigated lands by many types of sprinkler and surface-irrigation systems. Uniform water distribution by these systems is necessary to maximize crop yield and quality. Also, uniform water distribution is necessary for more efficient use of the available irrigation water supplies. For these reasons, improvement in water distribution by both sprinkler and surface irrigation systems is very important to irrigated agriculture (Pair, 1968).

Chávez et al. (2010) indicated that water uniformly applied within the irrigated area makes it possible to maximize yield, optimize nutrients uptake by plants and reduce problems of groundwater contamination due to leaching. These authors also stated that mechanical lateral-move irrigation systems have potential to cause high levels of water application uniformity.

It is important that linear moving sprinkler systems, which have been used in recent years, be used correctly. Knowing the amount of water supplied by the system and the water distribution pattern is of great importance for the proper use of the system. Sprinkler irrigation machine, which is used especially in frequently grown field crops, has the advantage that the labour requirement is very low, different irrigation doses can be applied easily, water losses are low, equipment does not remain in the field at the end of irrigation, and a high uniform water distribution is provided (Bahçeci, 2006). According to Duke (2006), operating pressure of the system and wind speed condition at the application time is very important and effect on the uniformity of water.

So we could be saying that the usage of linear-move irrigation machine would be very useful of irrigation at large areas. For this purpose, we tested these machines and evaluated some criteria of its. This test produces data to be used in computing the coefficient of uniformity, which can assist in system design and/or selection, and can be used to quantify certain aspects of system performance in the field. The coefficient of uniformity is only one factor in evaluating total system performance (ASAE, 2012).

MATERIAL and METHODS

Theory and modelling

Test procedure was prepared according to ASAE S436.1: 1996 standards (ASAE, 2012) to determine the performance of the linear moving sprinkler system used in the experiment.

If a portion of the area under the pipeline is used for the water supply system and not for crop production, that distance should not be included in the definition of the effective length. For this case, the effective length is the distance between the terminal sprinkler and spray devices on each end of the lateral, plus 75% of the wetted radius of each terminal water applications device, minus the distance used for the water supply system. For this case, the effective length is the distance between the terminal sprinkler and spray devices on each end of the lateral, plus 75% of the wetted radius of each terminal water applications device, minus the distance used for the water supply system. A collection of water distribution devices fitted to the outlets of a lateral move system. The devices may consist of sprinklers, spray devices, piping, pressure or flow control devices, and supporting plumbing designed for a specific machine and set of operating parameters (ASAE, 2012).

The Christiansen's distribution coefficient (CUc), one of the most important criteria used in determining water distribution performance, was developed by Christiansen (1942) and is also expressed in the literature as The Christiansen's distribution coefficient (CU). In terms of ensuring a distribution in sprinkler heads, distribution coefficient values are not required to be less than 84% (Çalgıcı, 2011).

The coefficient of uniformity for a lateral move is calculated using the Christiansen formula;

$$CU_c = 100\left[1-\frac{\sum_{i=1}|Vi-Va|}{\sum_{i=1}^{n}Vi}\right] \qquad \text{Eq.(1)}$$

where:

CUc : The Christiansen uniformity coefficient;

n : The number of collectors used in data analysis;

Vi : The volume of water collected in the i th collector (mL),

Va : The arithmetic average volume caught by all collectors (mL).

Test Conditions and Procedures

Collectors are placed parallel to the wing of the irrigation machine, perpendicular to the main pipe. The height of the collectors selected 120 mm. The collector was determined of a light color to reflect solar radiation and minimize evaporation. The collectors were located so those do not interfere with the measurement of water application as shown in Fig. 1. The wind speed was consistently observed by anemometer from the Meteorology station (Metos, serial number 00203626), which has been locating 150 m close to the work area, along the rest.

The desired test pressure was specified prior to the test. For many applications the specified test pressure should match the pressure used to design the sprinkler package on the machine. The test pressure was recorded and being maintained during the test to within ± 5% of the specified test pressure. The machine operated at a speed that will deliver an average depth of application of not less than 15 mm. The irrigation system operated long enough for the water application pattern to completely pass over all collectors (Fig. 2).

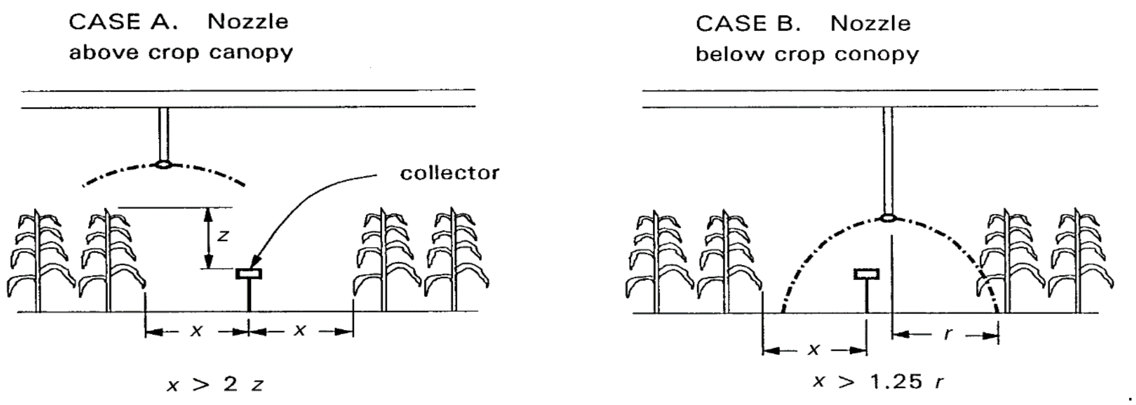

Figure 1. Collector layout for determining the water distribution of lateral move irrigation machines (ASAE, 2012)

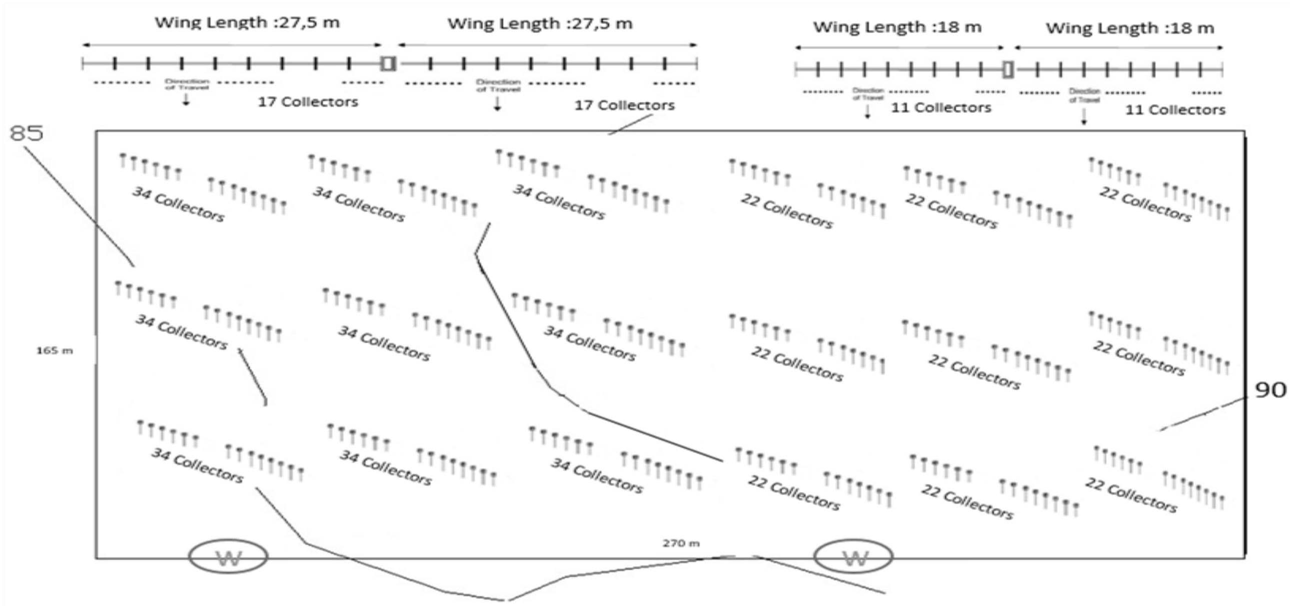

Figure 2. The layout of tests

RESULTS and DISCUSSION

In this study, the water distribution tests were performed according to standards and the Christiansen uniformity coefficient (CUc) were determined in order to control the uniformity of the water distribution throughout the wings. As we known that the Christiansen uniformity coefficient should be higher than 84% for being acceptable of water distribution.

The performance test was applied on 2 different types of irrigation movement machines that have different wing lengths, where 11 and 17 collectors were placed on the left and the right side of the wings. The amount of water collected in the collectors was measured, which was repeated as 3 replicates (Fig. 3). Figure 3 shows those different area topographic conditions in terms of altitude, position distance of water resources etc.

They were taken into consideration the wind velocity from 0.5 m s^{-1} to 2 m s^{-1}. Within the scope of the test, 6 mm nozzle diameter, 30, 40, and 50 m h^{-1} operating speed were used.

As a result of this study, when the speed of the Type-1 linear-move irrigation system was kept constant at 50 m h^{-1}, performance decreased when the wing height was measured at 1.8 m, 1.5 m and 1.0 m heights. On the other hand, when the speed of the linear-move irrigation system was kept constant at 40 m h^{-1} and 30 m h^{-1} speed, it was observed that the performance of the irrigation system was decreased by decreasing the height of the wing to 1,8m 1,5m and 1,0 m. Another result is that the CU distribution decreases when the wing height was kept constant at 1.8 m, 1.5 m and 1.0 m for each height and its performance at 50 m h^{-1}, 40 m h^{-1} and 30 m h^{-1} was measured.

As the test measurements were performed simultaneously, all climatic parameters were fixed for both irrigation systems. Therefore, when the two irrigation systems were compared, it was observed that the performance of Type-1 linear-move irrigation system increased when the height of the wing from the ground was decreased and the performance of the Type-2 linear-move irrigation system remained constant. Results of the tests have shown total and graphically on Fig. 3.

When the previous studies in the literature are examined, it is seen that the results obtained in the research coincide with the studies. In the researches, it is explained that the speed of linear move irrigation system, the wind speed during the operation of the machine and the equal water distribution are important in both water and plant nutrient applications. In addition, it is stated that timely and correct machine maintenance is effective in uniform water distribution (Howell & Phene 1983; Silveira et al. 1987; Fraisse et al. 1995; Omary et al. 1997; Bahçeci et al. 2008; Nörenberg et al. 2017).

CONCLUSIONS

Considering all the results, linear-move irrigation machine could be useful of large areas due to easy-use operating procedure, highly effective water distribution and etc. The tests have shown that the annual maintenance of the linear-move irrigation system has a significant effect on the decrease in CU. The other hand, the high initial investment cost can be considered as a disadvantage.

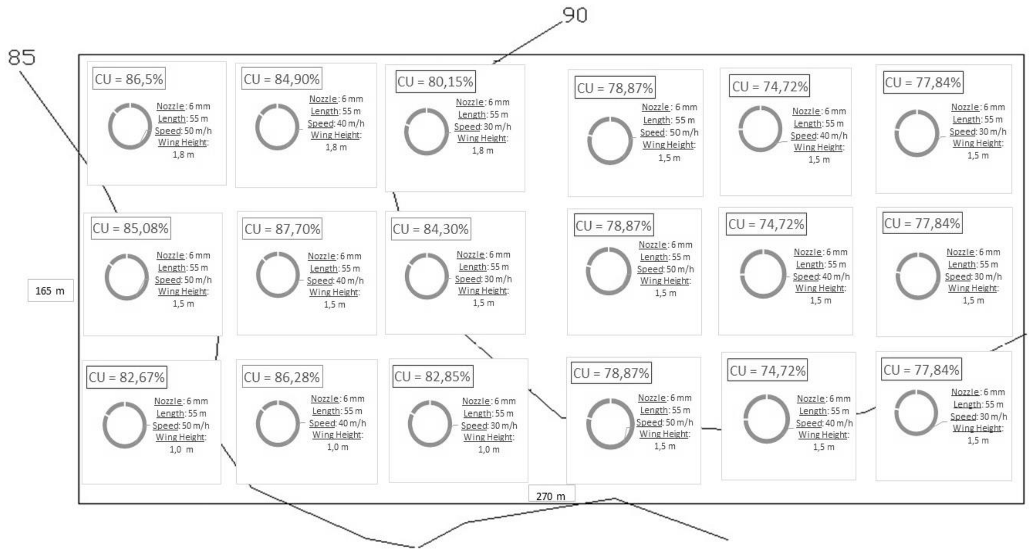

Figure 3. Graphical scenery of results of the machine tests

ÖZET

Amaç: Bu çalışmanın amacı, Trakya bölgesinde tarla bitkileri için yaygın olarak kullanılan hareketli yağmurlama sistemlerinin tasarımında dikkate alınması gereken eş su dağılım katsayılarının belirlenmesidir.

Yöntemler ve Bulgular: Araştırmada, sistem kanatları boyunca eş su dağılımının kontrolü amacıyla Christiansen eş su dağılım katsayısı (CU) ilgili standartlara göre test edilerek bulunmuştur. Test kapsamında başlıklarda 6 mm meme çapı, 30, 40 ve 50 m h^{-1} makine hareket hızı uygulanmıştır. Rüzgâr hızı, su uygulaması üzerinde oldukça önemli etkiye sahip olduğundan testler 0.5 m s^{-1} ile 2 m s^{-1} rüzgâr hızı aralığında gerçekleştirilmiştir. Performans testleri, kanatların sol ve sağ tarafına 11 ve 17 toplayıcının yerleştirildiği farklı kanat uzunluklarına sahip iki farklı doğrusal hareketli sulama sistemine uygulanmıştır. Toplayıcılarda toplanan su miktarları ölçülmüş ve Christiansen eş su dağılım katsayıları hesaplanmıştır. Sonuç olarak, Eş su dağılım katsayıları %74.72-86.50 arasında değişmiştir.

Genel Yorum: Test edilen makinelerin kanat yüksekliğinin ve uzunluğunun ayarlanabilir olması, akış ve hız kontrolünün elektronik panel ile yapılabilmesi gibi

üstünlükleri tespit edilmiştir. Ancak, makinelerin ürün yetiştiriciliğine paralel olarak test edilmesi ve geliştirilmesi önerilmektedir.

Çalışmanın Önemi ve Etkisi: Çalışmanın önemi, sistem performansının yükseltilmesi, tarla yüzeyinde eş su dağılımının sağlanması, su uygulama randımanının arttırılması ve paralelinde üretim kapasitesinin yükseltilmesi için makine üreticileri ve kullanıcılarına önerilerin geliştirilmesidir.

Anahtar kelimeler: Doğrusal hareketli sulama sistemi, performans testi, işletme özellikleri, ıslatılan alan

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DECLARATION OF CONFLICTING INTERESTS

The author(s) declare no conflict of interest for this study.

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